EFFECTS OF WATER MANAGEMENT ON FRESH-WATER DISCHARGE TO BISCAYNE BAY

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ABSTRACT

Prior to development in southeast Florida, fresh water discharge to Biscayne Bay consisted of flow through natural drainageways, overland flow, and coastal underseepage from the Biscayne aquifer. Through the years, the characteristics of the fresh-water flow have changed from natural, sporadic, short bursts of rainy-season flow through the low drainageways and prolonged dry-season coastal underseepage, to regulated discharge through drainage canals and decreased periods of coastal underseepage.

The fresh-water flow to Biscayne Bay has been significantly reduced in quantity and in time, due to extensive flood and water-control measures and water-management practices instituted after the extensive flooding of 1947. By the end of 1962, surface flows could be fully controlled in the Everglades by a system of levees and canals, water-conservation areas, pumps, and flow regulation structures. Thus, since 1953 annual fresh-water flow to Biscayne Bay has been reduced by about 20 percent and the duration of storm-water runoff has also been reduced. Flood control measures in south Dade County have altered the pattern of fresh-water flow to the Bay. Ground-water level recession rates in south Dade County are twice as rapid as they were before the implementation of flood control measures there. This means that the Bay receives fresh-water runoff for only about half as long after a storm as it did previously.

Implementation of planned water-management practices would result in further reduction of fresh-water runoff to the Bay. Further changes in south Biscayne Bay could be expected if urbanization in south Dade County approaches the density of that of Miami and vicinity.

INTRODUCTION

Biscayne Bay is a shallow tropical lagoon about 35 miles long, as much as 10 miles wide, and 12 feet deep (see fig. 1). It is bound on the west by the Mangrove Swamp of the mainland, on the east by a series of barrier and coral islands, on the south by Card Sound, and on the north by Dumfoundling Bay (U.S. Dept. of the Interior, 1973). Tidal range in the Bay is about 2.0 feet at North Miami and Coconut Grove and about 1.6 feet near Homestead and at Elliott Key (Schneider, 1969). Tidal range in the Atlantic Ocean at Miami Beach is about 2.4 feet.

Biscayne Bay receives fresh water from rainfall and runoff from the mainland. Rainfall over the Bay ranges from 46 inches per year at Miami Beach to 64 inches per year at Homestead and probably averages almost 60 inches per year over the entire Bay (U.S. Dept. of Commerce, 1974). The rainfall is seasonal; about 70 percent of the annual total falls during the rainy season, normally June through October. Rainfall varies considerably from year to year. During the last 35 years at the Miami station minimum rainfall was 37 inches in 1956 and maximum; 89 inches in 1959 (U.S. Dept. of Commerce, 1975).

DISCUSSION

Under natural conditions in southeast Florida, fresh-water discharged to the Bay from natural drainageways, by overland flow and by seepage from the Biscayne aquifer. Present day inflow to the bay is, seasonal, from controlled canals and seepage.

Under natural conditions most of the land in southeastern Florida, presently utilized for urban, subground, where flooding during the rainy season was less probable. In the 1900's because of major urban expansion in the vicinity of Miami, drainage canals were extended inland along natural drainageways, and through transverse glades (see fig. 2). Urban areas expanded westward on land formerly inundated or used for agriculture, displacing agriculture to land farther inland to the eastern edge of the Everglades.

The hydrologic regimen of the Lake Okeechobee-Everglades area has undergone continuous modification since settlement began late in the nineteenth century. Before drainage and land reclamation in the northern part of the Everglades, water levels in Lake Okeechobee and those in the Everglades adjacent to the lake were about the same during periods of high water; overflow occurred first at two low places on the south shore when water stages reached 15 feet - outflow along the south shore became general at a stage of about 18 feet. Modification of overland flow in the Everglades began when drainage canals and levees were built around Lake Okeechobee beginning in 1881. Most of the excavation for major drainage canals along the lower east coast was completed by 1932 — canals were either uncontrolled or inadequately controlled, and continuous drainage resulted in lowered ground-water levels and sea-water intrusion into the Biscayne aquifer in the Miami area (see fig. 3). After the 1943-45 drought, major canals through the coastal ridge were equipped with control structures, which prevented overdrainage during dry periods and prevented additional or reduced existent sea-water intrusion.

Extensive flooding which followed the heavy rains of 1947 demonstrated the need to improve the water-control systems. The 1947 flooding led to the establishment in 1949 of the Central and Southern Florida Flood Control District, whose functions were to furnish flood protection to urban and agricultural lands during rainy seasons and to provide facilities for conserving water for alleviation of the effects of drought. Work on new water-control facilities in collaboration with the U.S. Army Corps of Engineers proceeded during the 1950's; water Conservation Areas 1 and 2 were enclosed by levees in Palm Beach and Broward counties (fig. 1). By the end of 1962, water Conservation Area 3 was enclosed on the south side and for the first time, surface flow in the Everglades north of the Everglades National Park could be fully controlled. Conservation Area 3 was considered fully enclosed by July 1967. Additional changes and modifications in the water-management structures are planned for construction as needed. One of the modifications planned is to provide the capability of moving water to south Dade County during dry periods. Another planned modification is to backpump to the water conservation areas a part of the excess storm water that normally would flow to Biscayne Bay. The water conserved by backpumping would help sustain higher water levels during the dry season.

The prime effect of the water-control works in south Florida has been to facilitate the flow of water out of the Everglades by means of the canal system, thereby changing the spatial and temporal distribution of runoff from the Everglades. Prior to 1961, flow southward toward the Everglades National Park and south Dade County through the Tamiami Canal outlets, based on the 1941-61 record, averaged 252,600 acre-feet per year through the Levee 30 to Levee 67A section, 128,900 acre-feet per year through the Levee 67A to 40-Mile Bend to Monroe section. During 1962-68, average annual discharge through the Levee 30 to Levee 67A section was reduced to about 63,200 acre-feet, the discharge through the Levee 67A to 40-Mile Bend section increased to about 323,600 acre-feet, and the discharge in the 40-Mile Bend to Monroe section remained about the same. Adjustments in operation of canals and control structures to meet changing needs have changed the amount, timing, and distribution of seaward discharge of the Miami Canal which drains the Everglades and transects the coastal ridge. Reduction in flow to the ocean began with completion of the levee systems east of the three conservation areas in 1953. Discharge to the ocean through Miami Canal was reduced an average of 185,000 acre-feet per run-off year for 1956-65. Overall reduction of fresh water flow to the ocean since 1953 as a result of flood and water-control measures is about 20 percent of the fresh water that otherwise could have been discharged to the ocean in southeastern Florida (Leach, et al. 1972).

Before drainage, water levels were near or at land surface along much of the coastal ridge area. The principal effect of pre-1945 land-reclamation practices was the lowering of ground-water levels throughout the coastal ridge and interior areas. Overdrainage of many coastal areas allowed sea-water intrusion of canals and the Biscayne aquifer, the source of nearly all potable water in the area. During 1945, after a prolonged drought, salty water moved up the Miami Canal and intruded the Biscayne aquifer in the vicinity of the Miami well field, when water was being withdrawn at 30 Mgal/d (million gallons per day). The overdrainage has been arrested and, since 1954, water levels have tended to stabilize in most of Dade County (see fig. 3). Yearly peak water levels in coastal areas are considerably lower than in pre-flood-control times, and yearly low water levels are higher than in pre-management times. Thus, in 1971, in a similar dry season to 1945, and following installation of the salinity control structure in Miami Canal at Northwest 36th Street, water was being withdrawn at 95 Mgal/d; minimum water levels near the center of the field were lower than in 1945, but sea-water intrusion was controlled (Benson and Gardner, 1974). The improved conditions of well-field production and salinity control are results of salinity barriers in canals and replenishment of water in well-field areas from canals. Similar conditions prevail at other near-shore well fields in the southeast Florida area (Hull, 1975).

The effects of the new canal system and flood-control practices on the hydrology of south Dade County were also marked by a change in the recession rate of ground-water levels. Figure 4 shows selected graphs of parts of the water level recorded at well S-182, a short distance north of Canal 1 (see fig. 1 for location), to contrast the recession rates before and after Canal 1 and the salinity control S-21 was completed in December 1961. The graphs show that the recession rate for part of June 1961 (pre-canal construction) was about 0.2 foot per day, half the 0.4 foot following canal construction. The increase in the rate of recession indicates that the duration of runoff to the bay has been appreciably reduced.

ACKNOWLEDGMENTS

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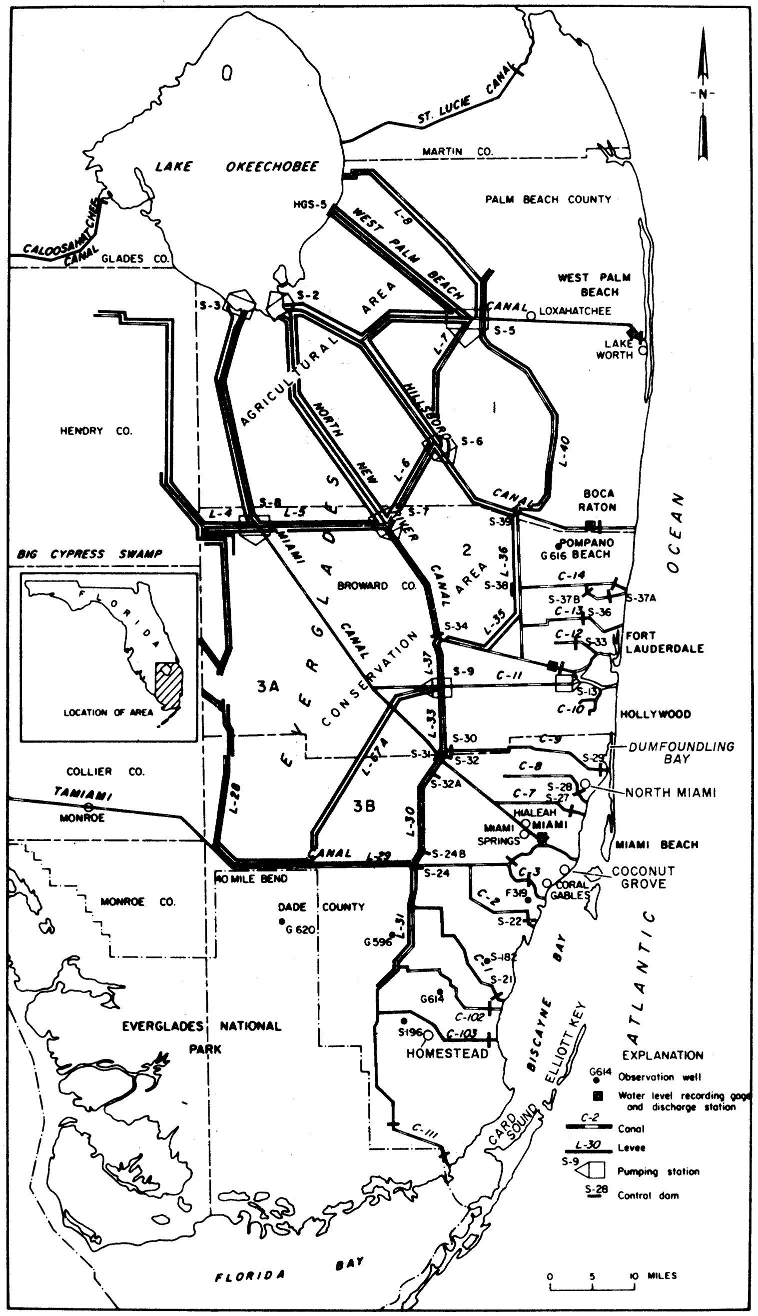

Figure 1. Central and Southern Florida Flood Control project structures and hydrologic features in southeastern Florida.

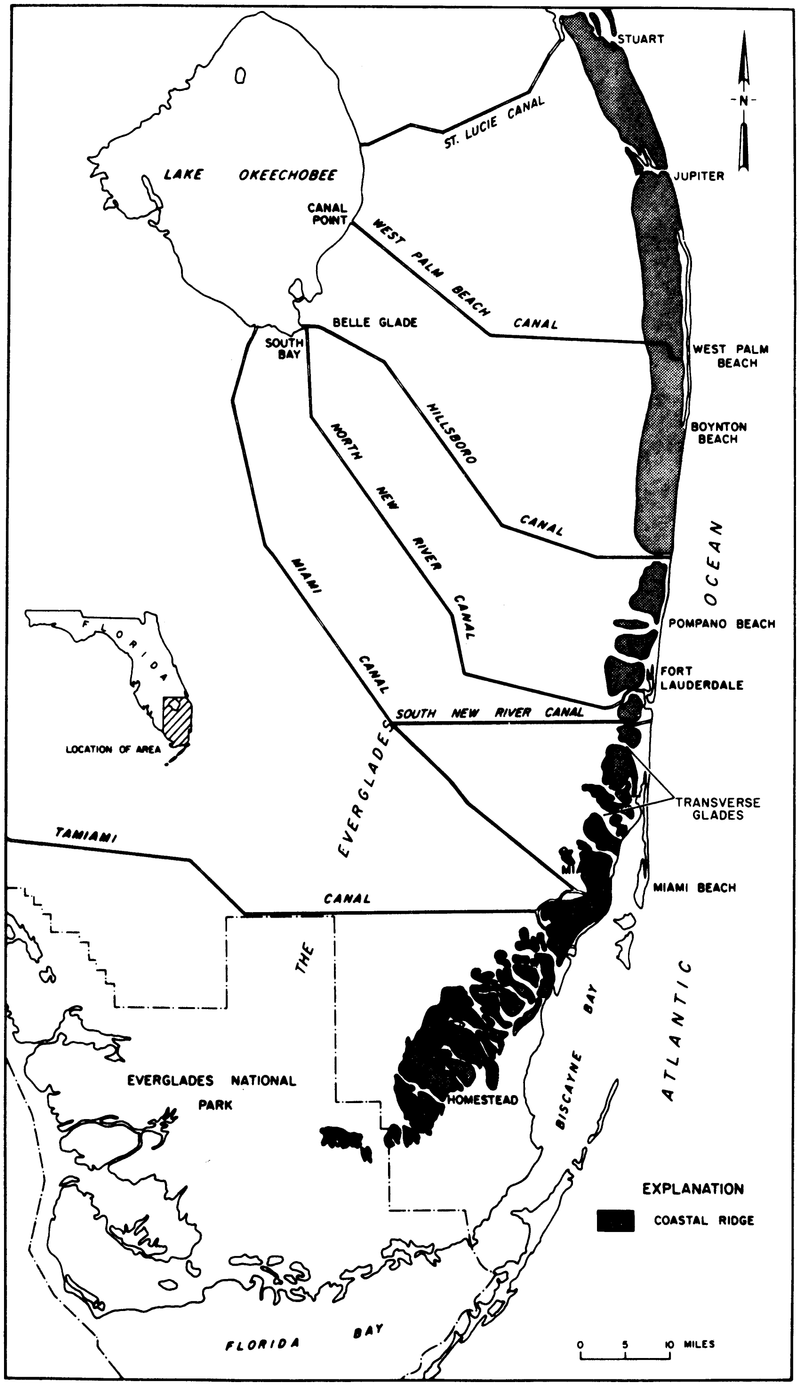

Figure 2. Florida's lower east coast showing the configurations of the natural drainageways (transverse glades) and locations of major canals through the coastal ridge.

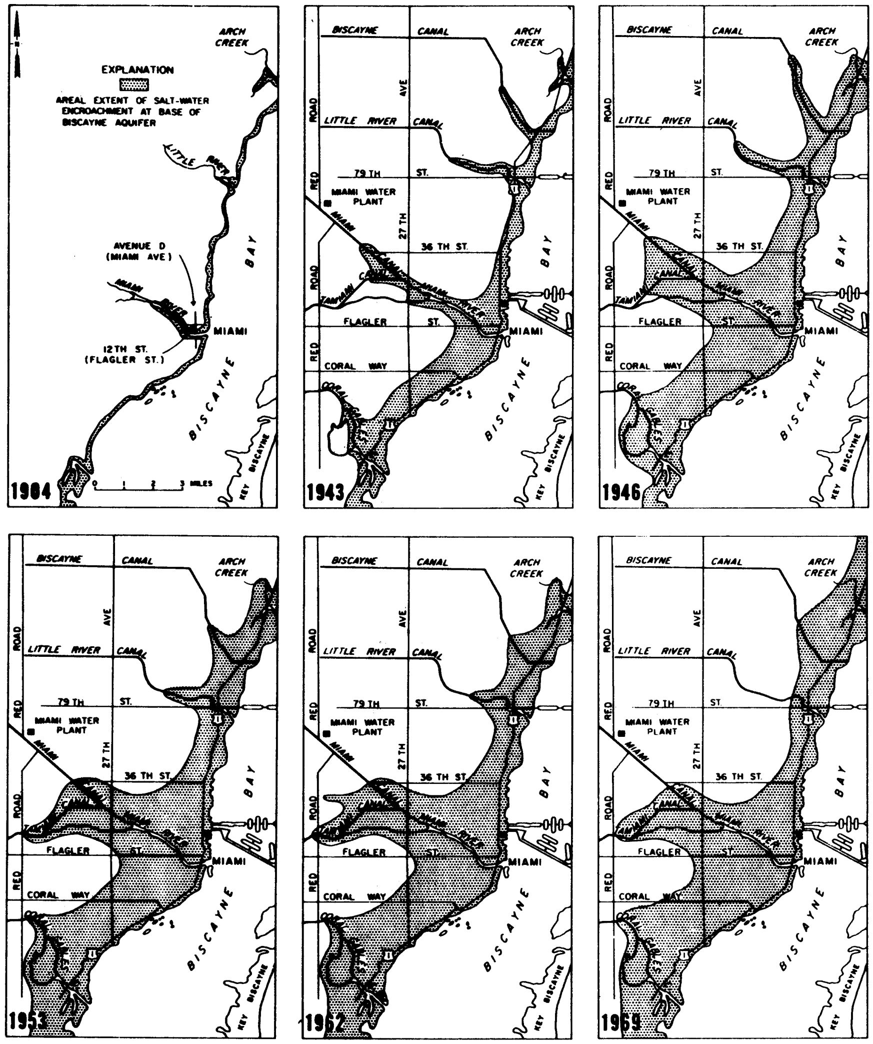

Figure 3. Miami area in eastern Dade County showing the sea-water encroachment at the base of the Biscayne aquifer 1904-69.

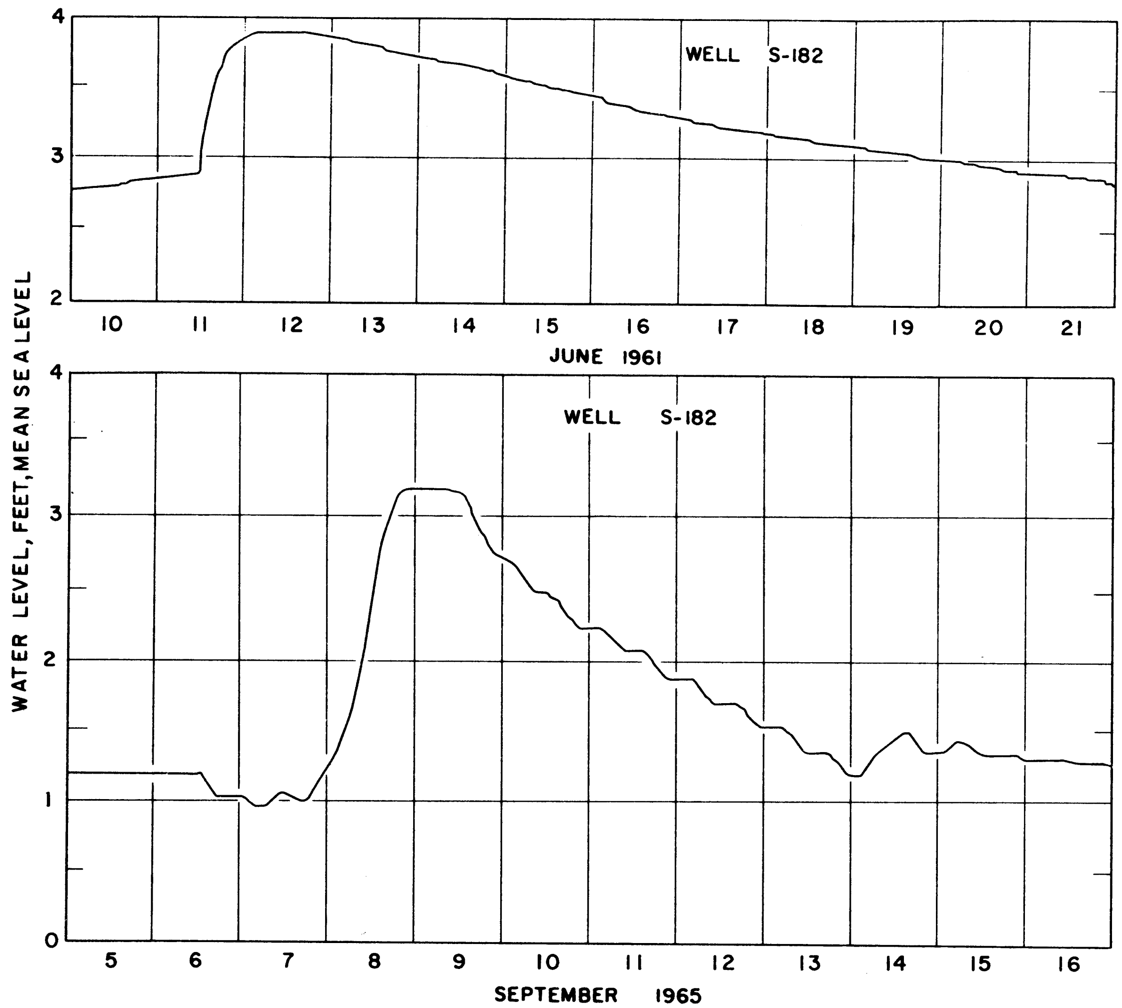

Figure 4. Hydrographs of well S-182 showing water-level recession rates before and after construction of Canal 1.